THE USE OF DRIED EGGS OF SUBSTANDARD QUALITY IN FOODS

by

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INTRODUCTION

Large quantities of dried eggs are purchased by the government for the use of the armed forces and for Lend-Lease. Due to factors of production and storage some of these are not of high quality and when prepared as directed have prompted unfavorable criticism of all dried eggs. If food combinations that include dried eggs of substandard quality and produce a palatable food were developed much of this unfavorable criticism could be avoided.

Little work has been done on methods of satisfactorily using eggs of substandard quality in food. Suggestions for uses of these eggs to produce palatable foods should be of value to all who must use them.

The purpose of this study was to determine some of the problems encountered in the use of dried eggs of substandard quality, some of the foods which may be combined with them to make a resulting product that is pleasing and palatable and methods of handling dried eggs of borderline quality in order to obtain the best results.

REVIEW OF LITERATURE

Since the beginning of the war there has been a tremendous increase in the production of dried eggs in the United States. According to Goresline (1943) in 1941 there were 10 egg-drying plants in the United States with a total capacity of 10,000,000 pounds of dried egg products per year. Statistics in the American Egg and Poultry Magazine for July, 1944, show a total pro-

duction of 119,152,000 pounds of dried eggs produced from January 1 to July 1, 1944. Figured in percentages this is 2283 percent more than the largest production in a six-month period before the war. This increase in production of dried egg products is largely due to the saving in shipping space, but it is also due to the better keeping qualities of the dehydrated eggs.

Although the history of egg drying dates back to about the middle of the 19th century, Le Clerc and Bailey (1940) described the resultant product as a horn-like powder, not used as food but by the leather, dye, photographic and paper industries. To prepare this powder the liquid egg was dried over direct fire in tin or zinc pans. The dried egg powder produced today is prepared by quickly drying the liquid egg. Johnson (1942) listed a number of different methods for drying eggs including spray-drying, pan-drying, vacuum-drying and drum-drying. He stated that at that time spray-drying was used almost exclusively. In this method of drying, the liquid egg is forced in a fine spray into the drying oven where it is dried almost instantly.

Le Clerc and Bailey (1940) reported that up to 1927 egg drying in the United States was done only experimentally, and up to the beginning of the war only small amounts were dried commercially. Some dried egg powder was imported from egg-drying plants in China for use in flour mixes or in bakeries without facilities to store fresh or frozen eggs.

The main cause of spoilage, according to Bumzahnow (1944), is bacteria and, since moisture is an essential requirement for the growth of bacteria, dehydration delays spoilage. Bate-

Smith, Brooks and Hawthorne (1943) stated that the keeping quality of the dried egg powder is a function of temperature and water content; as the percentage moisture in the egg powder increases changes occur at an increasingly low temperature. Thistle, White, Reid and Woodcock (1944) studied the effect of temperature of storage on keeping qualities and found some deterioration even at a temperature as low as -40° C. They also studied the effect of moisture content on the keeping qualities and found that a low moisture content had a marked preservative action; however, powders containing as low a moisture content as 1.4 percent suffered some deterioration at temperatures of 37° to 48° C.

Hawthorne (1943) reported that there was no correlation between flavor and moisture content in freshly prepared dried egg powder and only when the moisture content was below a certain critical stage was it correlated with beating power. He did, however, find a definite correlation between moisture content and deterioration on storage. This he thought to be due either to the initial high moisture content in the egg powder or to the packaging and the humidity during storage. Stewart, Best and Lowe (1943) agreed with this and further stated that storage temperatures above 20° C. were detrimental to solubility and fluorescence, the factors which they had selected as an index of quality in the dried whole egg.

Tracy, Sheuring and Haskisson (1944) studied the relationship of various storage temperatures to the usability of powdered egg yolk in ice cream and found that when stored at

room temperatures or above there was deterioration in the color, flavor, solubility and pH of the yolks. This agreed with Gane (1943), who reported that the rate of deterioration of the dried egg powder was determined by water content and temperature of storage. According to Marshall (1944) the army paid a premium for egg powder which had been stored at a temperature of less than 40° C. from the time of drying to the time of delivery. Burton (1944) stated that beginning January 28, 1944, the army specifications were for 2.0 percent moisture content in the egg powder purchased. He then predicted that before the war was over and a serious attempt was made to market dried eggs for home use, the residual moisture content would be reduced to 0.0 percent to 1.0 percent. These results were being obtained experimentally at that time.

The effect of a CO_2 pack on the keeping qualities of dried egg powder was studied by Thistle, White, Reid and Woodcock (1944) who found that it afforded some measure of protection, particularly on the degree of solubility of the powder.

The main requirement of dehydration, according to Bumzahnow (1944), is reversibility, that is, the production of egg powder which is readily restored to fresh egg quality and flavor. Marshall (1944) did not entirely agree with this requirement. He stated that perhaps the stage of perfection in which dried eggs taste exactly like fresh eggs can never be obtained, then he asked if that were really the goal any more than to make a prune taste like a plum or a raisin like a grape.

Hawthorne (1944) used four methods for determining the solu-

bility of egg powder and correlated his results with the reports of a tasting panel. He stated that the correlation between solubility and palatability does not include all types of deterioration; in general, solubility is an index to the deterioration during drying and/or storing. Creaming tests were used by Bate-Smith, Brooks and Hawthorne (1943) as a measure of solubility. When the egg powder was reconstituted and allowed to stand over night, the good egg remained homogeneous but the deteriorated egg separated, or creamed. Microscopic examination of the cream showed that small fat globules containing air were fused together. In extreme cases the egg separated entirely, leaving a clear liquid under the cream; thus, a high percent of creaming indicated a poor solubility. They believed that, in general, a sample of good flavor would be good in other respects, although some samples of good flavor and good solubility have poor aerating power.

According to Hawthorne and Bennion (1942), beating power is closely related to baking power, as judged by the quality of sponge cakes. They found that by working at a high temperature not only was the maximum volume of foam obtainable greatly increased, but also the rate of formation of the foam. By means of a high temperature and an added amount of water, to make up that which was lost by evaporation, good results were obtained with samples of egg powder that otherwise had poor baking qualities. They recommended that each sample of egg powder be tested for the optimum amount of water and the necessary beating time.

Jordan and Sisson (1943) substituted egg powder in a formula for muffins and for custards and found that approximately

13.5 g of powder were the equivalent of one liquid egg. However, they observed a large variation in different powders tested, and suggested that the manufacturers should state on the package the equivalent of the product.

Methods and modifications of methods which gave repeatable results in the determination of certain chemical and physical characteristics of spray-dried egg powder were described by Fryd and Hanson (1944). Using these methods, they devised a formula by which it was possible to predict flavor score of dried eggs to a useful degree of accuracy. This formula could be used to reinforce the opinion of the flavor-tasting panels and may prove in certain circumstances to be a rapid method of evaluating the quality of dried eggs without recourse to tasting.

When the dried egg powder was to be evaluated by tasting Wilson and Slosberg (1942) reconstituted the eggs and steamed them in an ordinary household egg poacher. They stated that it was better to overcook than to undercook in preparing eggs for tasting, and suggested that salt should not be added as it would tend to mask any off-flavor. They found that eggs having a score below 6.0 could be made acceptable for table use by the addition of suitable condiments.

In a recent article Cremeens (1944) stated that he believed that a market can be made for the dried egg products in the post-war world; however, it will require real salesmanship. The baker, the candy maker and other users of egg products who have their factories on either coast and purchase their eggs from the middle of the continent can be shown the saving in shipping and

storage costs by the use of dried rather than frozen or shell eggs, but unless it can be proven to him that he can use dried egg powder without sacrificing the quality of his products or losing any of his customers, he will not make the change. Because of the low quality of some of the dried eggs served to members of the armed forces in the Pacific and elsewhere, there are unfavorable reports of all dried eggs, and a salesman will have to overcome many prejudices before a large market will be available for dried eggs. Cremeens also believed that there can be a market for dried eggs in the home for use in baking, although not for use in omelets, scrambled eggs, custards or similar products.

According to a consumer survey reported in the United States Egg and Poultry Magazine (1944), 74 percent of 102 housewives questioned said that they might be willing to buy dried eggs. Of these, 26 percent were willing to buy them if the cost were less, 27 percent were willing to buy them if the cost were the same and 21 percent were willing to buy them if the cost were more than shell eggs. Twenty-six percent of the total number questioned said that they would not be willing to buy dried eggs at any price.

The initial quality and the keeping quality that can be developed in the dried egg powder are of utmost importance in determining the extent of the use of the powder in the post-war world. However, since much of the dried egg powder used by the armed forces has suffered some deterioration due to storage conditions, it is advantageous to know something of the ways that low quality dried eggs may be satisfactorily used for food.

PROCEDURE

The work with the substandard eggs was divided into two phases. In the first phase the dried eggs or the products in which they were used were evaluated by tests to determine their culinary characteristics and the types of recipes in which they might be successfully used. The tests were set up to determine the degree of creaming and to a certain extent the emulsifying quality, the binding ppwer, the aerating ability and the thickening power of the dried eggs.

The other phase was an application of these findings. The egg powder was used in various types of recipes which from the results of the first phase seemed likely to give satisfactory products. It was also combined with different foods in an attempt to find those which might be effective in covering any undesirable flavor of the dried egg. The products made were tomato-egg casserole, ham-egg casserole, carrot casserole, spinach casserole, liver dumplings, plain muffins, graham muffins, cake containing fat and gingerbread.

Ingredients

Four lots of dried eggs were used in this work. These were stored in the coldroom in Calvin Hall at approximately 40° F. from the time of delivery until used. They were packed in 15-pound cartons lined with vapor-moisture-proof cellophane bags and closed with the confectioner's seal. A quart carton was filled from the large carton and the eggs were used from this small carton. By the use of this method the major portion of the

eggs was not exposed to the air or subjected to a change of temperature until it was weighed and used.

The egg powders used in this study are described in Table 1. Egg powder in Lot I was dried to a 2.0 percent moisture content, which is according to present army specifications, and brought to the laboratory and stored immediately in the coldroom.

Egg Lots II and III were dried to a 5.0 percent moisture content at the same time, their only difference being the temperature at which they were stored. Lot IV was dried to a 2.0 percent moisture content; however, it was scorched during the drying process. Because of the scorching of Lot IV and the storage of Lot III at high temperature, it was expected that they would not have as high quality as Lot I and Lot II.

Table 1. Description of dried whole eggs used.

Egg Lot no.	Date dried	Date brought to laboratory	Reported moisture content %	Remarks
1	9/27/44	9/28/44	2	Brought to laboratory immediately
2	10/18/43	9/25/44	5	Stored at 35° F. until brought to laboratory
3	10/18/43	9/25/44	5	Stored at room temperature until brought to laboratory
4	9/23/44	9/25/44	2	Slightly scorched in drying

The ingredients used with the dried eggs were kept as nearly uniform as possible. Swans Down cake flour, Gold Medal all-

purpose flour, Calumet baking powder, Primex shortening, sugar, salt and distilled water were kept in the laboratory and Parkay margarine was kept in the refrigerator for use throughout the study. A 10-pound box of dried skim milk was obtained from the S & H Bakery in Manhattan, Kansas, on October 16, 1944. This was also kept in the refrigerator and with two exceptions was used throughout the study. All other ingredients were ordered fresh as needed.

Equipment

The equipment used was similar to that found in any well-equipped laboratory. Baking pans, sauce pans, measuring spoons, cups and all small utensils were standard.

A Hamilton Beach Model "D", 15-speed, electric mixer having two bowls, one of five-cup and the other of three-quart capacity, was used in mixing cream puffs, cakes and gingerbreads.

A Frigidaire electric stove was used for all cooking and baking. The oven temperature was checked with a Taylor oven thermometer.

The custards were baked in Pyrex custard cups of 150 cc capacity, each equipped with a cork supported by a narrow band of tin which was fastened across the cup to hold the bulb of a thermometer approximately in the center of the custard.

Temperatures were taken with a Centigrade chemical thermometer and time intervals were measured with an Eastman timer.

Method

All ingredients were weighed except the water and the flavorings. The water was measured in a 100 cc graduated cylinder and the vanilla, lemon extract and the Worcestershire sauce were measured in a standard measuring spoon.

In all of the products 13.5 g of dried egg powder were considered to be the equivalent of one egg. Approximately 50 g of water were used for each egg, although the amount varied with different products. The egg powder was reconstituted for use in everything except the cakes containing fat, muffins and gingerbreads. To reconstitute the eggs the volume of water to be used was measured into a 250 cc beaker and the sifted egg powder was put on top of the water, then mixed with a fork, using 125 strokes. The egg and water were allowed to stand for one hour, then mixed by an additional 50 strokes with the fork. When hard-cooked eggs were to be used the egg powder was reconstituted as above and mixed with 1.5 g of salt for each egg. The equivalent of two eggs was poured into a Pyrex baking dish 4.5 inches in diameter and 1.5 inches deep. The dish was covered and set in a steamer in which the water was rapidly boiling and steamed from 12 to 15 minutes. After the eggs were removed from the steamer they were diced into approximately one-fourth inch cubes and used immediately to prevent any discoloration which might occur upon standing.

The milk powder was reconstituted for all products except the muffins. To make the equivalent of one cup of fresh milk 21 g of dried skim milk powder and 227 g of water were used. The

water was measured into a bowl and the milk powder sifted into it, then beaten with a rotary egg beater for one minute. The total amount of milk needed for the day was calculated and that quantity was reconstituted, then weighed as it was needed.

TESTS FOR THE CULINARY CHARACTERISTICS OF THE DRIED EGGS

As preliminary work, objective tests were made upon the dried eggs or the products in which they were used, to determine some of the problems which might be encountered in using them. The extent of creaming in the reconstituted egg was first determined as a measure of solubility. Cream puffs were made to measure the emulsifying and binding power; sponge cakes the aerating ability and baked custards the thickening power of the dried eggs.

Creaming Test

The extent of the creaming of a reconstituted egg may be correlated with the solubility of the egg powder. Bate-Smith, Brooks and Hawthorne (1943) stated that a high percentage of cream denoted a low solubility which, in turn, is to some extent a measure of deterioration. They suggested that to measure the extent of creaming, the dried egg powder be reconstituted in the proportion of one part egg powder to three parts of water. Thirty grams of egg powder and 90 g of distilled water were used. After the egg had reconstituted for one hour it was mixed with 50 strokes and poured into a 100 cc graduated cylinder. The following morning the height of the cream and the height of the entire column were measured in millimeters. The measure of creaming

was the height of the cream in percent of the height of the column. The results recorded were the average of two tests.

The results of the creaming test indicated a large difference in the four lots of dried eggs, as is shown in Table 2. Lot I and Lot II had little or no creaming which indicated a high solubility and is correlated with high quality. Lot III and Lot IV had a much higher percentage creaming which is considered an indication of low solubility and low quality. These results are in line with what would be expected since Lot I had been freshly dried and Lot II had been stored at a low temperature, while Lot III had been stored at room temperature for a year and Lot IV had been scorched in drying.

To determine the emulsifying and binding power of the dried eggs, cream puffs were made by the following formula.

Cream Puffs

Temperature: 425° F. Time: 40 minutes

Ingredients	Approximate measure	Weight in grams
All-purpose flour	1/4 c*	27.5
Salt	1/8 t	0.8
Egg powder	1/4 c	13.5
Water	1/2 c	120.0
Fat	1/8 c	25.0

Method

1. Sift flour and salt together three times.
2. Reconstitute egg with 60 g of water.
3. Melt fat in 60 g of water and heat to boiling point.
4. Add flour and salt and mix with wooden spoon 30 seconds (mixture should cling to spoon).
5. Pour into five-cup mixing bowl and cool one minute; add egg.
6. Beat with electric mixer at speed three (low) for 15 seconds.
7. Change to speed 15 (high) and continue to beat for a

*c = cup, t = teaspoon, T = tablespoon

Table 2. Results of tests for culinary characteristics of dried eggs.

Egg lot no.	Cream-ing %	Cream puffs volume (cc)	Sponge cakes: Specific gravity Foam	Specific gravity Batter	Consistency (min)	Tenderness (g)	Compressibility (ml)	Volume (cc)	Custards: Curdtension (g)	Standing height (cm)	Crust weight (g)	Syneresis (g)
I	0.0	142.7	.49	.56	5.3	---	1.8	405.0	27.0	2.7	9.8	11.0
II	2.1	142.9	.42	.45	7.3	70.5	3.4	633.0	35.0	2.8	9.7	12.7
III	15.4	133.4	.61	.68	5.3	---	---	347.0	8.0	1.9	16.5	5.3
IV	33.3	72.4	.91	1.06	2.3	---	---	160.0	---	---	8.8	---

total of five minutes.
8. Scrape down with rubber scraper at the end of one-half, two and a half and four and a half minutes.
9. Weigh three puffs onto oiled baking sheet, using 120 g of batter for all puffs.
10. Bake.
11. Remove from oven and measure volume immediately.

Cream puffs were made from each lot of eggs three times. The volume of each puff was measured by means of seed displacement and the average recorded. The volume was measured by putting the puff in a can having a capacity of 590 cc. From a funnel, approximately 20 cm above the can, 490 cc of seed were allowed to run onto the puff. This was sufficient to fill the can rounding full. The excess seed was then scraped from the top of the can with a straight-edge and the volume measured in a 100 cc graduated cylinder. This volume of seed plus 100 equaled the volume of the cream puff in cubic centimeters.

As was shown in Table 2, there was only a slight difference in the cream puffs made with eggs from Lot I and Lot II. The volume was good and the crusts were crisp with little or no sogginess inside. Lot III made an acceptable cream puff, although the volume was less and there was a correspondingly larger amount of sogginess inside. Lot IV produced a cream puff of small volume, with a greasy crust and with the major portion of the egg and flour in the center of the puff in a soggy mass. The puff was definitely not acceptable.

The aerating capacity of the dried eggs was tested by the use of sponge cakes which were made by the following formula.

Sponge Cake

Temperature: 375° F. Time: 24 minutes

Ingredients	Approximate measure	Weight in grams
Sugar	1/3 c	66.6
Salt	1/2 t	0.5
Cream of tartar	1/3 t	1.0
Cake flour	1/3 c	33.3
Baking powder	1/3 t	1.5
Egg powder	1/2 c	27.0
Water	3/8 c	90.0
Vanilla	1/3 t	--

Method

1. Sift sugar, salt and cream of tartar together three times.
2. Sift flour and baking powder together three times.
3. Put 40 cc of water in five-cup mixing bowl and heat to 75° C.
4. Sift egg powder into bowl and beat with electric mixer at speed 15 (high) for 30 seconds; scrape.
5. Continue beating at speed 15; add sugar gradually during next 15 seconds; scrape; beat 45 seconds more; scrape.
6. Add 50 cc of boiling water, one tablespoon at a time, during next minute; beat for a total of five minutes; scrape.
7. Record temperature and specific gravity.
8. Change to speed two (low), add vanilla, then flour and baking powder during one minute; scrape.
9. Beat 30 seconds longer.
10. Record temperature, specific gravity and consistency.
11. Pour into unoiled sponge cake pan and bake.

The specific gravity determinations were made by filling a 57.7 cc cup with batter, weighing it and recording the weight in grams. The specific gravity was calculated by dividing the weight of the batter sample by the weight of an equal volume of water.

The consistency of the batter was determined by putting the sample used for the specific gravity test into a glass funnel, which had two marks two inches apart on its stem, the bore of which was approximately 8.0 mm in diameter. The time needed for

the batter to move from the upper mark to the lower one was recorded as the measure of consistency.

Approximately 20 hours after baking the volume of the cakes was measured. The same ring-stand and funnel were used as in measuring the volume of the cream puffs. The capacity of the empty sponge cake pan had been determined and this volume of seed less 100 cc was used in measuring the volume of the cake. Without removing the cake from the pan the seed were allowed to run directly onto the cake from the funnel. The excess of seed was then scraped from the pan by means of a straight-edge and measured in a graduated cylinder. This volume of seed plus 100 cc equaled the volume of the cake in cubic centimeters.

The cake was then removed from the pan and tested for compressibility and tenderness.

In order to insure uniform slices of cake for testing compressibility, each slice was cut by means of a metal gauge one inch deep. One cut was made in the cake, then the gauge was slipped into the cake and the one-inch slice cut with a sharp knife. Three such slices were used for the compressibility test.

The apparatus for this test was similar to that described by Platt and Kratz (1933) and used by Fulks (1936), Miller (1942), Buck (1943) and Tinklin (1944). It consisted of a remodeled laboratory balance and an Eastman timer. Under the right-hand pan of the balance was fastened a metal plunger 31 mm in diameter. The cake sample was placed on an adjustable platform below the plunger so that the plunger rested easily up-

on it. A 10 g weight placed on the pan held the plunger to the surface of the cake. The left-hand pan of the balance held a linked chain which exactly balanced the 100 g weight in the right-hand pan. A wooden drum extended over the left-hand pan so that the chain could easily be wound from the pan to the drum by means of a handle, thus allowing the weight to act upon the plunger. A pointer was suspended from the cross-arm to a scale at the lower part of the balance and indicated the compression in millimeters. The average reading for three samples was recorded as the compressibility.

For the tenderness test three one-inch cores of cake were cut by means of a sharpened cylinder. Tenderness was then determined by a mechanical device as used by Reed (1931) and by Miller (1942) in studies on angel food cakes. The device consisted of a ring-stand which supported a short horizontal beam from which was suspended a wooden clamp for holding one end of the cylindrical sample of cake. A similar wooden clamp which supported a very light-weight copper pan was fastened to the lower end of the cake sample. The metal rings were adjusted so that the sample was firmly held between the fingers of the wooden clamps. The ring-stand also supported a glass container which held fine dustless sand. The flow of sand was controlled by means of a spring which was connected with a rubber stopper by a thin wire. When not in use the wire was held taut by the spring, but when pressure was applied to the spring the stopper was released and the sand poured slowly into the small copper pan until the cake sample was broken. The weight in grams of the clamp, the cake and the pan

of sand represented the force necessary to break the cake. Three such samples were tested and the average recorded as the tenderness or the tensile strength.

The best sponge cakes were made with eggs from Lot II (Table 2). The average volume was 633 cc which was more than 200 cc larger than the average volume of the cakes made from Lot I; the other two cakes were even smaller. Results of experimental work in this laboratory, using the same methods and proportions of ingredients as were used in this test, showed that dried egg powder with good aerating ability will make sponge cakes with a volume of 925 to 950 cc, which indicates that none of the egg powders used in this study had optimum aerating ability. The foam and the batters of the cakes made in this test also indicated poor aerating ability. Hawthorne and Bennion (1942) reported 0.33 as optimum specific gravity for the foam of sponge cakes made from dried egg powder. The specific gravity nearest 0.33 in this test was 0.42, the specific gravity of the foam made from Lot II. All others were higher. As is shown in Table 2, the specific gravity of the batters was in the same order as that of the foam, but the batter with the lowest specific gravity had the greatest consistency. This, too, was no doubt due to the inclusion of more air in the batter.

The cakes made from Lot II were the only ones which could be measured for tenderness since there was insufficient height in the other cakes to obtain a sample for the test. Cakes from Lot III and Lot IV could not be tested for compressibility for the same reason. Cakes from Lot I gave a small compressibility read-

knife was directly over the platform. The curd knife was a circle 4.5 cm in diameter having eight knives 1.5 cm. long attached to the inside of the circle with the cutting sides sharpened to a knife edge. This curd knife was attached to a spring scale which indicated the maximum pressure exerted on the curd knife. The custard with the surface removed was placed on the platform and raised by use of the hydrolytic pump to the curd knife at a uniform rate until the knives cut the surface of the custard. The resistance encountered by the knives in passing through the custsrd wss read in grams directly from the scale. The average reading was recorded as the curd tension.

With the aid of a spatula the custards were loosened from the cup, turned out onto a plate and their height measured in centimeters. The custards were then covered to prevent evaporation. On the following morning the syneresis was measured by pouring the custard into a sieve and allowing the liquid to drain from the solid into a weighed cup.

The custards made with eggs from Lot I and Lot II were comparable in standing height, crust weight and syneresis (Table 2); however, the curd tension of Lot I was less than that of Lot II and soon after it was turned out on the plste the curd broke. Lot III made a custard which had a heavy, thick crust that was easily separated from the custard and gave a low-curd tension reading. When this custard was removed from the custard cup it settled quickly and by morning was completely flat. However, it was of a thick consistency and very little would go through the sieve. The custard made with Lot IV had a thin crust and gave no measur-

able resistance to the curd tension knife. When it was removed from the cup it flattened immediately. The entire custard went through the sieve so syneresis could not be measured.

Discussion of Results

The tests on culinary characteristics of the dried eggs showed those in Lots I and II to be definitely superior to those in Lots III and IV. The results of the creaming test showed both Lots I and II to have a high solubility. Both lots of eggs made good cream puffs. This was assumed to mean that both the binding and the emulsifying qualities of the eggs were retained, as otherwise a small, greasy puff would have resulted. The aerating quality of the eggs was less well preserved. Eggs from Lot II produced a fair sponge cake but one which was inferior to sponge cakes made in this laboratory with other dried eggs. Eggs from Lot I made a poor sponge cake, one which was small in volume and solid. Eggs from both Lots I and II made acceptable custards as might be expected from the high solubility shown in the creaming test. However, even in this product Lot II showed some superiority.

It would seem, then, as a result of these tests that either of these powders could probably be used satisfactorily for products that did not require extensive aerating power in the egg. They should be usable in many main dishes, hot breads, cakes containing fat, puddings and other similar products.

Lot III was only moderately soluble as was shown in the creaming test. Although it made a fair cream puff, indicating some retention of the binding and emulsifying qualities, it gave

very poor results in sponge cakes and custards. Thus it was assumed that this egg could not be used satisfactorily in products which depended upon the egg for aerating or thickening qualities. However, it seemed that it might be used in baked goods leavened by carbon dioxide and added to creamed foods and to other dishes where the nutritive value of the egg was of importance and the other culinary properties played a minor part.

The egg powder from Lot IV had low solubility as was shown by the results of the creaming tests. The cream puffs made from this egg powder were flat and greasy which would indicate a lack of emulsifying and binding power; also a lack of aerating ability and of thickening power was shown by the results of the sponge cake and the custard tests. Thus, on the basis of these tests, it appears that egg powder from Lot IV could not be expected to be satisfactorily used in any cooking where these qualities are necessary.

PALATABILITY OF THE DRIED EGGS IN FOODS

After the four lots of eggs had been tested to determine, to some degree, their culinary characteristics they were judged for palatability, then used in nine selected recipes and the products scored by the palatability committee. Due to the results obtained in Part I, no recipes were used in which the egg was the major source of emulsification, binding, aeration or thickening power. The products chosen for use were tomato-egg casserole, ham-egg casserole, carrot casserole, spinach casserole, liver dumplings, plain muffins, graham muffins, cake containing

fat and gingerbread.

The products selected were made two times from each of the four lots of dried egg powder. Each of the series was made simultaneously if possible, or consecutively on the same day if the facilities available made this necessary. The cakes and the gingerbread were scored the morning after they were baked; all other products were scored as soon after preparation as was expedient. Score sheets were prepared for each series of products which were scored by a palatability committee consisting of five members of the staff of the Department of Food Economics and Nutrition.

The muffins were also measured for volume and the cakes tested for tenderness, compressibility and standing height. Temperatures, specific gravities and consistency of the cake batter were recorded.

Effect of Dried and Fresh Milk on Dried Egg Flavor

In an attempt to compare the effect of fresh whole milk and dried skim milk upon the flavor of dried eggs, a bacon strata was made. Egg powder from Lot III was first used for this test; however, since it was of low quality, all of the products were inferior. It was thought that this might influence the results so the test was repeated as before, using egg powder from Lot II. The following formula was used.

Bacon Strata

Temperature: 325° F. Time: Approximately 45 minutes

Ingredients	Approximate measure	Weight in grams
Egg powder	1/4 c	13.5
Water	3 T	45.0
Stale bread	1 1/2 slices	32.0
Bacon	1 1/2 slices	30.0
Bacon fryings	1 T	14.0
Salt	2/3 t	4.0
Milk	3/4 c	183.0

Method

1. Reconstitute egg in water.
2. Remove crusts from bread, cut into one-inch strips and arrange one-half to fit the bottom of oiled casserole.
3. Fry bacon and arrange on top of bread.
4. Pour bacon fryings over bread.
5. Arrange remainder of bread on top of bacon.
6. Combine egg, milk and salt; pour over bread.
7. Bake until knife inserted in center comes out clean.
8. Score, using Form I.

There was no consistent difference in the scores for the products made from the dried milk and those made from the fresh milk. Since dried milk was readily available and more easily kept the same from day to day, it was used in making all other products in Part II.

Flavor Score

The dried eggs were reconstituted in the ratio of one part egg powder to three parts distilled water by weight and hard cooked by the method previously described, except that no salt was added. They were scored as soon as they were removed from the steamer. Each member of the palatability committee was given a one-fourth inch cube of hard-cooked egg from each of the four lots. The official standards for palatability scores for dried

eggs, prepared by the War Food Administration on May 10, 1944, were used to judge the flavor of the eggs (American Egg and Poultry Review, 1944).

Official U. S. Standards for Palatability
Scores for Whole Dried Eggs

Score	Description of Quality
8.0	No detectable off-flavor, comparable to high quality fresh shell egg.
7.5	Very slight off-flavor.
7.0	Slight but not unpleasant off-flavor.
6.5	Definite but not unpleasant off-flavor.
6.0	Pronounced off-flavor (slightly unpleasant).
5.0	Unpleasant off-flavor.
4.0	Definite unpleasant off-flavor.
3.0	Pronounced unpleasant off-flavor.
2.0	Repulsive flavor.
1.0	Definite repulsive flavor.
0.0	Pronounced repulsive flavor.

The average scores given by the palatability committee were as follows: Lot I, 7.2; Lot II, 6.8; Lot III, 3.8; and Lot IV, 0.7. The egg powders were given approximately the same average score for the two times they were tasted, and also they were given similar scores by the different members of the committee. All of the judges except one scored the egg powder from Lot I higher than that from Lot II. The range for Lot I was 6.5 to 8.0 and for Lot II was 5.0 to 8.0, which was the widest range of scores given, one member of the committee scoring it 5.0 and another 8.0 both times. The scores for the egg powder for Lot III ranged from 3.0 to 5.0 and for Lot IV the range was 0 to 1.0 which was the most consistent score.

Fryd and Hanson (1944) reported that a score of 5.0 to 6.0 indicated an egg of borderline acceptance for consumption, and a score of less than 5.0 an egg with a flavor such as to make it

unacceptable for consumption. According to this report, the scores given by the palatability committee indicated that only Lot I and Lot II had flavors suitable for general household use.

Casserole Dishes

Four casserole dishes were made with the dried eggs. In two of these the eggs were hard-cooked; in the others they were reconstituted and added to a white sauce. In each casserole dish the eggs were combined with a different food flavor. The same score card was used for the four products as they were similar, also the results are discussed together. The following formulas were used.

Tomato-Egg Casserole
(Two servings)

Temperature: 400° F. Time: 20 minutes

Ingredients	Approximate measure	Weight in grams
Egg powder	1/2 c	27.0
Water	1/2 c	120.0
Salt	1/2 t	3.0
Margarine	3/4 T	10.5
Flour	1 1/2 T	10.3
Salt	1/4 t	1.5
Tomato juice	2/3 c	163.0
Onion, minced	1/2 T	5.3
Celery, diced	2 T	16.5
Green pepper, diced	2 T	17.5
Worcestershire sauce	1/8 t	--
Milk	1/6 c	40.7
Dry bread crumbs	1/4 c	22.0

Method

1. Reconstitute egg powder in water; add salt and hard cook.
2. Make sauce of margarine, flour, salt and tomato juice.
3. Add onion, celery, pepper and Worcestershire sauce.
4. Cool slightly; add milk.
5. Cut eggs into one-fourth inch cubes; combine with above mixture.
6. Pour into oiled casserole.

7. Cover with bread crumbs.
8. Bake.
9. Score according to Form I.

Ham-Egg Casserole
(Two servings)

Temperature: 400° F. Time: 20 minutes

Ingredients	Approximate measure	Weight in grams
Egg powder	1/2 c	27.0
Water	1/2 c	120.0
Salt	1/2 t	3.0
Margarine	3/4 T	10.5
Flour	1 1/2 T	10.3
Salt	1/4 t	1.5
Milk	3/4 c	183.0
Cured ham, cubed one-fourth inch	1/3 c	48.0
Stale bread, cubed one-fourth inch	1/2 c	30.0
Bread crumbs	1/4 c	22.0

Method

1. Reconstitute egg powder in water; add salt and hard cook.
2. Make white sauce of margarine, flour, salt and milk.
3. Cut egg into one-fourth inch cubes.
4. Combine egg, ham and bread with sauce.
5. Pour into oiled casserole.
6. Cover with bread crumbs.
7. Bake.
8. Score according to Form I.

Carrot Casserole
(Two servings)

Temperature: 325° F. Time: Approximately one hour

Ingredients	Approximate measure	Weight in grams
Egg powder	1/4 c	13.5
Water	3 1/3 T	50.0
Margarine	1 T	14.0
Flour	1 T	6.9
Salt	1/3 t	2.0
Milk	1/3 c	81.5
Onion, minced	1 t	3.5
Orange rind, grated	1 t	0.8
Pepper	1/12 t	0.2
Raw carrot, grated	1/2 c	56.0

Method

1. Reconstitute egg powder in water.
2. Make sauce of margarine, flour, salt and milk.
3. Add onion, orange rind, pepper and carrot.
4. Combine egg and sauce.
5. Pour into oiled casserole.
6. Bake until knife inserted in center comes out clean.
7. Score according to Form I.

Spinach Casserole
(Two servings)

Temperature: 325° F. Time: Approximately one hour

Ingredients	Approximate measure	Weight in grams
Egg powder	1/4 c	13.5
Water	3 1/3 T	50.0
Margarine	1 T	14.0
Flour	1 T	6.9
Salt	1/2 t	3.0
Milk	1/3 c	81.4
Onion, minced	1 t	3.5
Lemon rind, grated	1/3 t	0.8
Pepper	1/12 t	0.2
Frozen spinach	1/2 c	100.0

Method

1. Reconstitute egg in water.
2. Thaw spinach sufficiently to cut into small portions.
3. Make sauce of margarine, flour, salt and milk.
4. Add onion, lemon and pepper.
5. Combine egg and spinach.
6. Combine two mixtures.
7. Pour into oiled casserole.
8. Bake.
9. Score according to Form I.

The casserole products made with egg powder from Lot I and Lot II were in all cases acceptable to the members of the palatability committee (Table 3). The scoring by the committee was consistent throughout, and although the total scores varied slightly all products were given scores of more than 21 out of a possible 25. These slight differences were probably not significant. There was no great difference in the scores for the

Table 3. Summary of score data for casserole dishes.

	Egg lot no.	General appearance	Color	Odor	Consistency	Taste	Total score	Acceptability
Possible score		5.0	5.0	5.0	5.0	5.0	25.0	1.0
Tomato-egg casserole	I	4.7	4.3	4.3	4.8	4.9	23.0	1.0
	II	4.7	4.3	4.6	4.8	5.0	23.4	1.0
	III	3.9	3.5	3.5	2.9	2.8	16.6	0.5
	IV	1.6	1.4	1.4	0.9	0.7	6.0	0.0
Ham-egg casserole	I	4.2	3.9	4.3	4.4	4.5	21.3	1.0
	II	4.6	4.8	4.3	5.0	4.8	23.5	1.0
	III	3.2	3.2	2.7	2.9	1.9	13.9	0.1
	IV	1.2	1.1	1.0	1.1	0.5	4.9	0.0
Carrot casserole	I	4.6	4.4	4.6	4.6	4.8	23.0	1.0
	II	4.8	4.8	4.4	4.6	4.4	23.0	1.0
	III	3.6	3.9	2.5	3.3	3.3	16.6	1.0
	IV	1.1	1.3	0.9	1.9	1.8	7.0	0.1
Spinach casserole	I	4.5	4.9	4.8	4.7	4.8	23.7	1.0
	II	4.6	5.0	4.7	4.7	4.6	23.6	1.0
	III	3.6	4.0	3.2	3.7	3.2	17.7	0.8
	IV	2.2	2.4	1.5	2.4	1.8	10.3	0.2

individual characteristics, none of them being less than 3.0. No score was less than 4.0 for taste of the products made from these eggs. The spinach casserole which had the highest total score received a perfect score for color and seldom less than that for consistency and taste.

Approximately one-half of the time the products made with egg powder from Lot III were acceptable to the palatability com-

mittee. However, the tomato-egg casserole and the ham-egg casserole were acceptable an average of 0.3 of the time while the spinach and carrot casseroles were acceptable an average of 0.9 of the time. This was probably due to the tendency of the egg powder from Lot III to become tough and too bright a yellow when hard cooked. When the reconstituted egg was combined with a sauce, as was done in the spinach and carrot casseroles, neither of these faults appeared; thus the scores for color and consistency of these products were equal to the other scores, while the scores for color and consistency for the tomato-egg and the ham-egg casseroles which contained hard-cooked egg were much lower.

The products made with the egg powder from Lot IV were given consistently low scores and were acceptable to the palatability committee only twice. The same member of the committee marked the spinach casserole acceptable both times it was judged. Although all of the scores were low, the lowest were for taste and for odor, the highest score for either of these being 3.0. This score was received when the spinach casserole was served. When hard cooked, the egg powder from Lot IV had an unpleasant brown color and a grainy texture and could not be combined with the other ingredients without crumbling. This gave an unpleasant appearance and an undesirable consistency to the tomato-egg and the ham-egg casseroles. In the spinach and carrot casseroles the consistency was more nearly acceptable but the dark brown color was still apparent.

According to these results egg powder from Lot I and Lot II may be satisfactorily used in casseroles, either hard cooked or

in combination with a white sauce and vegetables; egg powder from Lot III was not satisfactory when hard cooked, but could be combined with the white sauce and vegetables; and egg powder from Lot IV could not be recommended for use in either type of casserole product, largely because of its undesirable flavor and color and its consistency when hard cooked.

Since the unpleasant off-flavors and the brown color of the dried eggs from Lot IV seemed to be the principal disadvantages in using them, a liver dumpling was made with the four lots of eggs in the hope that the brown color and distinct flavor of the liver would be effective in concealing these undesirable qualities in the eggs. The following formula was used.

Liver Dumplings
(Four servings)

Ingredients	Approximate measure	Weight in grams
Egg powder	1/4 c	13.5
Water	3 1/3 T	50.0
Liver, ground	3/4 #	375.0
Margarine	1/2 T	7.0
Onion, minced	1/2 t	1.8
Lemon rind, grated	1/4 t	0.2
Pepper	1/12 t	0.2
Salt	1/2 t	3.0
Nutmeg	1/24 t	0.1
Poultry seasoning	1/24 t	0.1
Bread crumbs	1/3 c	29.3

Method

1. Reconstitute egg in water.
2. Combine all other ingredients.
3. Stir into egg; let stand one hour.
4. Shape into small balls one inch in diameter.
5. Roll in flour.
6. Drop in gently boiling clear bouillon; when they rise to top cover and cook four minutes longer.
7. Score according to Form I.

Table 4. Summary of score data for liver dumplings.

Egg lot no.	General appearance	Color	Odor	Consistency	Taste	Total score	Acceptability
Possible score	5.0	5.0	5.0	5.0	5.0	25.0	1.0
I	3.5	3.8	3.9	3.6	3.9	18.7	1.0
II	3.7	4.1	3.8	3.7	4.0	19.3	1.0
III	4.2	4.2	3.9	4.1	4.2	20.7	1.0
IV	4.3	4.0	3.7	4.1	3.8	20.4	1.0

The liver dumplings made with all four lots of egg powder were acceptable to the palatability committee. The scores given to the products made with egg powder from Lot I and Lot II were less than for the products made from Lot III and Lot IV. These results were not in agreement with results of other products made previously for products containing the egg powder from Lot I and Lot II had consistently rated higher. The scores for the four powders varied only slightly, indicating that the quality of the eggs had little effect upon the quality of the product.

There was approximately one-fourth egg per serving in the liver dumplings which was much less than in the casserole dishes, thus the quality of the egg would probably have less effect upon the product. The liver used in the dumplings was strong in flavor and the color was dark, thus the egg would have had little if any effect on the scores given for taste, odor and color. The scores for these characteristics did not vary greatly between the products made from different egg powders. The largest variation in scores given was for general appearance and for consistency. Egg

powders from Lot III and Lot IV had less thickening power than the powdere from Lot I and Lot II; thus the liver dumplings made with the powders from Lot III end Lot IV made a lese firm ball. On this point there was much difference of opinion among the members of the palatability committee, and the range of scores given was from 0.0 to 5.0. When all were averaged, however, the less firm dumplings had the highest score for coneistency, and the higheet total score.

According to the reeults of the scoring by the palatability committee any of the egg powdere could be used in combination with liver.

Muffine

An important use of eggs is in hot breads of which muffins are typical; hence, it wae thought advieable to study the effect of using the four lots of dried eggs in muffins. Plain muffins were made first, then in an attempt to lessen the effect of the egg on flavor and color of the product, the graham muffine were made. The following formules were used.

Plain Muffins

Temperature: 400° F. Time: 20 minutes

Ingredients	Approximate measure	Weight in grame
Flour	1 c	110.0
Egg powder	2 T	6.8
Milk powder	2 T	10.6
Sugar	1 T	12.5
Salt	1/2 t	3.0
Baking powder	1 1/2 t	6.1
Fat, melted	2 T	28.0
Water	9/16 c	133.5

Method

1. Sift flour, egg, milk, sugar, salt and baking powder together three times.
2. Add fat to water.
3. Add liquid to dry ingredients; combine with 17 strokes.
4. Weigh 30 g of batter into each of eight oiled muffin pans.
5. Bake.
6. Remove from pans and measure volume immediately.
7. Score according to Form II.

Graham Muffins

Temperature: 400° F. Time: 20 minutes

Ingredients	Approximate measure	Weight in grams
Flour, all-purpose	3/4 c	82.5
Flour, graham	1/4 c	30.0
Egg powder	2 T	6.8
Milk powder	2 1/4 T	11.8
Sugar	1 T	12.5
Salt	1/2 t	3.0
Baking powder	1 1/2 t	6.1
Fat, melted	2 T	28.0
Water	5/8 c	152.7

Method

1. Sift all-purpose flour, graham flour, egg, milk, sugar, salt and baking powder together three times.
2. Add fat to water.
3. Add liquid to dry ingredients; combine with 17 strokes.
4. Weigh 30 g of batter into each of eight oiled muffin pans.
5. Bake.
6. Remove from pans and measure volume immediately.
7. Score according to Form II.

As is shown in Table 5, the plain muffins made with egg powder from Lots I, II and III had a slightly larger volume than the graham muffins from these powders, but this was not true of those made with egg powder from Lot IV. The muffins made from Lots I and II were slightly larger than the muffins made from Lots III and IV; however, there was little difference in the volume of any muffins made in this study.

All of the muffins were acceptable to the members of the

Table 5. Summary of data for volume and palatability of muffins.

Egg lot no.	Volume	Acceptability	General appearance: Symmetry	General appearance: Top	General appearance: Surface	Color: Exterior	Color: Interior	Moisture	Texture	Lightness	Tenderness	Taste	Odor	Total soore
					Plain muffins									
I	57.5	1.0	1.5	1.3	1.6	1.8	1.7	1.5	1.5	1.6	1.4	1.9	1.8	17.6
II	59.0	1.0	1.5	1.4	1.7	1.7	1.8	1.8	1.4	1.7	1.7	1.9	1.8	18.4
III	54.1	1.0	1.7	1.6	1.7	1.7	2.0	1.8	1.2	1.4	1.6	1.6	1.2	17.5
IV	49.5	0.6	1.8	1.3	1.4	1.0	0.2	1.3	1.2	1.2	1.0	0.5	0.5	11.4
					Graham muffins									
I	56.5	1.0	1.7	1.6	1.4	1.2	1.8	1.9	1.6	1.8	1.8	1.9	2.0	18.7
II	56.3	1.0	2.0	1.9	1.8	1.7	1.8	1.8	1.6	1.6	1.9	1.9	1.9	19.9
III	52.5	1.0	1.7	1.7	1.8	1.5	2.0	1.6	1.6	1.6	1.6	1.5	1.4	18.0
IV	51.6	1.0	1.9	1.9	1.8	1.9	1.9	1.5	1.6	1.3	1.3	1.1	1.0	17.2

palatability committee with the exception of the plain muffins made with egg powder from Lot IV, which were acceptable only 0.6 of the time. In general the graham muffins made with egg powder from Lots I, II and III received the same or a slightly higher score than the corresponding plain ones; however, the differences in total scores were not large enough to justify a recommendation of one over the others.

The graham muffins made with egg powder from Lot IV scored higher in all characteristics and had a total score 5.8 points greater than those made with all-purpose flour. The largest difference was in color; the plain muffins had an unpleasant dark color with small specks of egg throughout the muffin which was apparent both from the exterior and the interior, but this was not noticeable in the muffins made with graham flour. This color of the exterior of the muffin probably influenced the scores given for appearance of the top and the surface of the graham muffins which were higher than the scores for the plain ones. The taste and odor of the graham muffins was also much more acceptable to the palatability committee than that of the plain muffins.

According to these results, graham muffins could be made satisfactorily with any of the egg powders used in this experiment, but the egg powder from Lot IV would not be satisfactory for making plain muffins.

Another important use of eggs is in cakes. The following formula was selected for testing the action of the dried eggs in a cake containing fat.

Cake Containing Fat

Temperature: 365° F. Time: 40 minutes

Ingredients	Approximate measure	Weight in grams
Sugar	1 c	200.0
Salt	1/4 t	1.5
Flour, cake	1 3/4 c	168.0
Baking powder	2 1/2 t	10.0
Fat	3/8 c	75.0
Water	6 2/3 T	100.0
Egg powder	1/2 c	27.0
Milk	2/3 c	162.7
Lemon extract	1/2 t	--
Vanilla	1/2 t	--

Method

1. Sift sugar and salt together three times.
2. Sift flour and baking powder together three times.
3. Sift egg powder.
4. Line bottom of pan 7 1/4 x 7 1/4 x 1 3/4 inches with waxed paper.
5. Combine milk, lemon extract, vanilla and 25 cc of water.
6. Put fat in five-cup mixing bowl, cream at speed eight (medium) for five minutes; scrape.
7. Add sugar and salt gradually during five minutes; scrape.
8. Add 75 cc water in five additions during next 75 seconds; scrape.
9. Continue to cream to the desired specific gravity.
10. Record specific gravity, time of creaming and temperature of mixture.
11. Change to speed two (low); add egg powder in thirds, mix 30 seconds and scrape before each addition.
12. Change mixture to three-quart mixing bowl.
13. Add one-fourth of flour and baking powder, mix 30 seconds, scrape, mix one minute, scrape.
14. Add one-third liquid ingredients, mix 30 seconds, scrape.
15. Repeat step 13 and step 14 until all of liquid is used.
16. Add remainder of flour; mix one minute, scrape, mix one more minute, scrape.
17. Record specific gravity, temperature and consistency of batter.
18. Pour into pan; cut with spatula 12 times in each direction.
19. Bake.
20. Remove from oven; cool five minutes.
21. Loosen with spatula; invert on wire rack and allow to fall from pan.
22. Remove waxed paper from bottom of cake; turn cake to upright position.

23. When cool place on cookie sheet; cover with larger pan.
24. Make tests and score according to Form III.

Specific gravity determinations and consistency measurements for cakes containing fat were made the same as for sponge cake. The other tests were made approximately 20 hours after baking. The cakes were cut by means of an apparatus similar to a mitre box, made of hardwood closed at both sides and at one end, with a kerf on each side one inch from the closed end into which fitted a long knife. Four uniform slices were cut from the cake. The first one was discarded because of the crust on one side; the other three were saved for the tests. The cake was then turned in the box and the remainder cut into uniform slices. The five middle slices thus cut were wrapped in waxed paper for the members of the palatability committee.

The height of each cake was determined by measuring in centimeters the fourth slice at the center, the outer edges and at points one-half the distance from the center to each edge. The average of the five measurements was recorded as the standing height.

The shortness of the cake was measured by means of a gram shortometer, an apparatus consisting of a modified spring balance and a remodeled laboratory balance as described by Kramer (1935), Fulks (1936) and Tinklin (1944), which measured in grams the force necessary to break a slice of cake one inch in thickness. On the weighing pan of the spring balance were two parallel bars three inches apart on which was placed the slice of cake to be tested. A third bar, suspended from the right-hand pan of the

remodeled laboratory balance was adjusted to apply pressure on the cake at a point midway between the two parallel bars. The dial of the balance was adjusted to zero. On the right-hand pan was placed a 250 cc glass beaker. Water was syphoned into this at a constant rate. The force necessary to break the cake was indicated by two movable hands rotating on the face of the spring balance. Upon breaking, one hand remained stationary for reading the breaking force; the other returned to zero. The three one-inch slices were tested on the shortometer and an average of these readings recorded as shortness of the cake.

After testing for shortness, one-half of each broken slice was used for the compressibility tests, which were made with the same apparatus as was used for the sponge cakes, except that a 200 g weight replaced the 100 g weight on the right-hand pan and was balanced by an addition to the linked chain in the left-hand pan. By this means more pressure was applied to the cake. As before, the average of three readings was recorded.

The temperatures of the room, of the creamed mixture and of the batter are recorded in Table 6. There was a range in room temperature of approximately one degree Centigrade during the time the cakes were being mixed, which was to be expected, as there was no means of regulating the temperature in the room, and baking was done in the laboratory where the cakes were mixed. The temperature of the creamed mixture and of the batter tended to vary with the room temperature. The fat, sugar and water were creamed to the desired specific gravity and the time of creaming recorded. The time of creaming was practically the same for the four mixtures

which might be anticipated, since the same ingredients were used and there was little difference in the temperature.

The thickest batters, as indicated by the length of time it took the batter to flow from one mark to the other on the stem of the funnel (Table 6) were made with eggs from Lot III and Lot IV, and were of approximately the same consistency. The batters made with egg powder from Lot I and Lot II were only slightly thinner. All of the batters were smooth and creamy in appearance, except the one made with egg powder from Lot IV which contained flecks of the egg, probably due to the low solubility of this powder which prevented it from being well dispersed in the mixture. These flecks were also noticeable in the baked cake. Any difference in the quality of the cake which might be correlated with the consistency of the batter was not evident. This might have been expected, as the difference in consistency was slight.

The volume of the cakes, as indicated by the standing height (Table 6), was approximately the same for those containing egg powder from Lots I, II and III. The cake made with egg powder from Lot IV was about 20 percent smaller than each of the other three. Cakes containing egg powder from Lots I and II were about equally tender as is shown by the shortness in Table 6, and they varied only slightly in compressibility. Cakes made with egg powder from Lot III were more tender and definitely more compressible. These results were no doubt due to the decreased binding power of the egg powder as was indicated in the tests for culinary characteristics. The cake made with egg powder from

Lot IV was so tender as to be somewhat crumbly; this, too, might have been expected, as the early reeulte with cream puffs indicated that thie powder had little or no binding and emulsifying power. Due to the small volume and the solid crumb thie cake showed small compressibility, which is contrary to what might be expected if only the tendernese of the cake were considered.

Ae is ehown in Table 7, the palatability committee found only small differences in the cakes made with egg powder from Lot I and Lot II, and except for color of crumb and eating quality the cake made from Lot III was eimilar. The cake containing egg powder from Lot IV was ecored down on all points but was coneidered most inferior in color of crumb and eating quality. This cake had a dark undeeirable color and a definitely dieagreeable flavor. There wae also a compact layer at the bottom of the cake and a tendency to crumble easily.

According to the resulte of this test the egg powder from Lot I and Lot II could be satiefactorily used in cakes containing fat. The egg powder from Lot III could no doubt be ueed in a variety of highly flavored simple cakee but would probably not be euitable for one in which much dependence was placed upon the egg for binding and lifting power. Egg powder from Lot IV could hardly be recommended for use in cakes, for even if no dependence were placed upon it for phyeical-chemical properties it is probable that flavor and odor would etill make it uneatisfactory.

The unpleasant flavor of the dried egg wae the greateet criticism of the use of the dried egge in cake containing fat. Hence the following gingerbread formula was eelected in an attempt to

Table 6. Summary of data for tests on cakes containing fat.

Egg lot no.	Temperature: Room °C	Temperature: Creamed mixture °C	Temperature: Batter °C	Time of creaming (min)	Specific gravity: Creamed mixture	Specific gravity: Batter	Consistency (min)	Standing height (cm)	Shortness (g)	Compressibility (mm)
I	27.5	26.8	26.0	14.3	.56	.73	3.3	4.9	111.0	2.5
II	27.8	26.5	26.0	14.5	.56	.73	3.8	4.9	110.0	2.9
III	27.8	26.3	26.0	14.4	.56	.75	4.9	4.8	99.0	3.4
IV	26.8	25.8	25.5	14.5	.56	.73	5.0	3.9	69.0	2.6

Table 7. Summary of palatability data of cakes containing fat.

Egg lot no.	General appearance: Crust	General appearance: Shape	General appearance: Color of crumb	Texture: Crumb	Texture: Tenderness	Texture: Velvetiness	Texture: Eating quality	Total score	Rating
I	85.3	82.3	93.6	86.2	89.9	84.6	89.6	611.5	2
II	89.5	90.5	92.4	85.2	85.3	87.0	89.3	619.5	1
III	89.7	87.4	83.3	84.7	84.5	86.8	80.4	596.8	3
IV	79.4	79.3	57.0	65.4	77.1	73.0	59.0	491.2	4

eliminate this fault.

Gingerbread

Temperature: 350° F. Time: 55 minutes

Ingredients	Approximate measure	Weight in grams
Sugar	3/8 c	85.5
Salt	3/16 t	1.1
Flour, all-purpose	15/16 c	103.1
Soda	3/8 t	1.5
Cinnamon	3/4 t	1.0
Ginger	3/4 t	1.1
Fat	2 2/3 T	37.5
Water	1/2 c	120.0
Egg powder	3 T	10.2
Molasses	3/8 c	123.6

Method

1. Sift eugar and salt together three times.
2. Sift flour, eoda, cinnamon and ginger together three times.
3. Sift egg powder.
4. Line bottom of pan 7½ x 3¼ x 2½ inchee with waxed paper.
5. Add 90 cc boiling water to molasses; stir.
6. Put fat in five-cup mixing bowl, cream at speed eight (medium) for four minutes; scrape.
7. Add sugar and salt, cream four minutes; scrape.
8. Add 30 cc water; cream two minutes.
9. Change to speed two (low).
10. Add egg, mix two minutes, scraping ae needed.
11. Add one-fourth flour mixture, mix 15 seconde; ecrape; mix 45 seconds.
12. Add one-third liquid; mix 30 seconds, ecraping as needed.
13. Repeet step 11 and step 12 until liquid is all ueed.
14. Add remainder of flour, mix 30 seconde; scrape; mix one minute.
15. Pour into pane, cut with spatula six times each direction.
16. Bake.
17. Remove from oven, cool five minutes.
18. Looeen from pan with epatula; invert pan on wire rack and allow to fall from pan.
19. Remove waxed paper from bottom; turn to upright poeition.
20. When cool place on cookie eheet; cover with larger pan.
21. Meaeure standing height and score according to Form III.

As is indicated by the standing height (Table 8) the volume

Table 8. Summary of data for standing height and palatability of gingerbreads.

Egg lot no.	Standing height (cm)	Rating	General appearance			Texture			Eating quality	Total score
			Crust	Shape	Color of crumb	Crumb	Tender-ness	Velvet-iness		
I	4.2	1	86.7	88.5	87.7	86.4	89.6	84.3	87.2	610.4
II	4.2	2	86.6	86.9	87.6	86.3	87.7	82.9	85.6	603.6
III	4.1	3	88.7	87.7	91.6	86.6	87.0	83.2	85.0	609.8
IV	3.6	4	75.0	72.3	84.2	74.4	74.9	75.8	72.7	529.3

of the gingerbreads made with egg powder from Lots I, II and III was approximately the same, while that of the gingerbread made with egg powder from Lot IV was about 12 percent less than the others. There was only a small difference in the gingerbreads made from Lots I, II and III, although, as is shown by Table 8, they were rated by the palatability committee in the same order in which they were numbered. The gingerbread from Lot III was not scored down for eating quality as was the case for the cakes containing fat. This was probably due to the spices and the molasses used in the gingerbread which effectively concealed the undesirable flavor evident in the cake.

The gingerbread made with egg powder from Lot IV was scored down on all points; however, it was not given as low a score for color of crumb or for eating quality as was the case with the cake containing fat. This, too, was probably due to the effect of the spices and molasses used in the gingerbread which almost completely concealed the unpleasant flavor of the egg. The gingerbread, like the cake made from Lot IV, had a solid crumb and a tendency to crumble easily. Although this gingerbread was not of standard quality it was probably an acceptable product.

According to these results all four of the powders used in this work might be used to make a gingerbread, although the egg powder from Lot IV did not make a product of optimum quality.

Discussion of Results

All of the products made with egg powder from Lots I and II were of acceptable quality which might have been expected from

the results of the tests on culinary characteristics as they indicated that these two lots of egg powder had retained to a fair degree all the qualities for which they were tested with exception of aeration.

The products made with egg powder from Lot III were not acceptable in all cases. They were not satisfactory when hard-cooked, but when added to a white sauce and combined with a food flavor which concealed the unpleasant flavor of the egg they gave good results. They were also satisfactory when used in muffins and gingerbread and acceptable in cakes containing fat.

The products made from egg powder from Lot IV were not entirely satisfactory in any case; however, with a distinct flavor such as liver, spices and molasses it might be possible to use this egg powder with fair results, providing the product is not dependent on the egg for emulsifying, binding, aerating or thickening power.

SUMMARY

The purpose of this study was to determine some of the problems encountered in the use of dried eggs of substandard quality; to find some foods which might be combined with them to make a resulting product that was pleasing and palatable; and to determine some of the methods of handling these eggs in order to obtain the best results.

Four samples of dried eggs were selected for use in this study. The eggs in Lot I were dried just previous to the beginning of this study to a 2.0 percent moisture content. The eggs in

Lots II and III were dried to a 5.0 percent moisture content. The eggs in Lot II were stored a year at approximately 30° F. and those in Lot III for the same length of time at room temperature. The eggs in Lot IV were dried just before the beginning of the study to a 2.0 percent moisture content, but they were scorched during the drying process.

The work was divided into two phases. In the first phase the following tests on culinary characteristics were made upon the dried eggs: Extent of creaming; emulsifying and binding power; aerating ability; and thickening power. In the second phase the eggs were scored for flavor by a palatability committee and were then used in the following prepared foods: Tomato-egg casserole; ham-egg casserole; carrot casserole; spinach casserole; liver dumplings; plain muffins; graham muffins; cakes containing fat; and gingerbreads. The quality of these foods was judged by the palatability committee.

The creaming test showed the recently dried unscorched eggs (Lot I) and those stored for a year at 30° F. (Lot II) to be highly soluble. The eggs stored at room temperature (Lot III) and those scorched in the drying process (Lot IV) had a high percentage cream, indicating low solubility. Solubility is considered a measure of quality, hence these results indicate that the eggs in Lots III and IV were of substandard quality.

The results with cream puffs were practically identical for Lots I and II and were only slightly less desirable for Lot III. Eggs from Lot IV failed entirely to produce a cream puff, indicating that these eggs had lost their binding and emulsifying qualities.

Only the eggs in Lot II had retained an appreciable amount of aerating ability, according to the results with sponge cakes, and this was considerably below the optimum for dried eggs.

The eggs in Lots I and II had retained, to a fair degree, their thickening power, as was indicatad in the tasts with custards. Eggs in Lot III showed little thickaning power and those in Lot IV practically none.

The results of the flavor score based on a ranga of zero to eight were as follows: Lot I, 7.2; Lot II, 6.8; Lot III, 3.8; and Lot IV, 0.7. A score of less than 6.0 indicates thst the egg is unsuitable for household use, hence only the eggs from Lots I and II had an acceptable flavor.

The products made with egg powder from Lots I and II were acceptable to the palatability committee in all cases. About three-fourths of the products made with egg powder were from Lot III, but only one-third of the products made with egg powder from Lot IV were acceptable.

The egg powder from Lot III did not make a product that was acceptable to the palatsbility committee when it was hard cooked and combined with foods which would concaal the unplaasant flavor of the egg, but it was accaptable when reconstituted and added to a whita sauce, then combined with such foods.

The cakes containing fat and the plain muffins made with egg powder from Lot III were sceptable but a more satisfactory product resulted with the addition of distinct flavors such as ara found in graham flour, spices and molasses.

The egg powder from Lot IV was never entirely satisfactory; however, the results indicated that even this powder was acceptable when combined with sufficiently distinct food flavors and when no dependence was placed upon the physico-chemical characteristics of the dried egg.

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Appendix

Form I

Score Card for Casseroles and Liver Dumplings

Food scored _____

Name _____ Date _____

	Product No.			
	A	B	C	D
1.				
2.				
3.				
4.				
5.				
Total				
Acceptability				

Form Ia

Directions for Scoring Casseroles and Liver Dumplings

1. General appearance of serving - - - - - - - - - 5
2. Color and/or color combinations - - - - - - - - 5
3. Odor - - - - - - - - - - - - - - - - - - 5
4. Texture and/or consistency - - - - - - - - - - 5
5. Taste - - - - - - - - - - - - - - - - - - 5

Total score - - - - 25

Indicate with + or - sign whether or not dish is acceptable.

Form II

Score Card for Muffins

Name _____ Date _____

	Product No.			
	A	B	C	D
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				
11.				
Total score				
Acceptability				

Form IIa

Directions for Scoring Muffins

Score	0	1	2
Appearance	1. Not symmetrical		Symmetrical
	2. Peaked or knobbed top		Definitely rounded top
	3. Smooth surface		Pebbled surface
Color			
a. exterior	4. Dark brown or pale		Golden brown
b. interior	5. Yellow spots or evidence of unmixed flour		
Moisture	6. Dry or soggy		Slightly moist
Texture	7. Large holes or tunnels		Medium size, fairly uniform holes
Lightness	8. Heavy		Light
Tenderness	9. Hard or tough		Tender
Odor	10. Disagreeable		Pleasing
Flavor	11. Flat or unpleasant flavor		Pleasing

Total possible score - - 22

Indicate with + or - sign whether or not dish is acceptable.

Form III

SCORE CARD FOR CAKES

Date_____ Sample No.

	Perfect (No Detectable Fault)	Remarks				
General Appearance	1. CRUST-Entire crust should be an even golden brown-Not too thick nor too thin-Not blistered, sugar, or greasy.					
	2. SHAPE-Symmetrical-Top should be smooth and only slightly rounded-No cracks or bumps					
	3. COLOR OF CRUMB-Even and rich looking-No objectionable color					
Texture	1. CRUMB-Should be springy and elastic-Even grain, i.e., cells small and uniform in size-Not too compact-Cell walls should be thin and fine.					
	2. TENDERNESS-Tender but not too light and feathery-Not tough or gummy.					
	3. VELVETINESS-Smooth and soft like velvet to tactile sense; (finger and palate).					
Eating quality	This includes all the qualities that make a cake agreeable or disagreeable for eating-Especially flavor, aroma, velvetiness or pleasing texture.					

Which cakes do you prefer?

1st Choice_____
2nd Choice_____
3rd Choice_____
4th Choice_____

Signature of Judge_____

Form IIIa

Directions for Use of Score Card for Cakes

Abbreviations to be used in scoring:

Perfect - X	No detectable fault
Excellent - E	Of unusual excellence but not perfect
Good - G	Average good quality
Fair - F	Below average, slightly objectionable
Poor - P	Objectionable but edible
Bad - B	Highly objectionable (not edible)

(+ or -) may be used where fine distinctions are to be made. Thus, if two samples are good in flavor but one slightly better than the other but not excellent, mark one G+ and the other G-.

Note appearance of each sample and score before tasting.
Note texture and score crumb.
Taste sample and score remaining points.

Any remarks as to why certain samples were graded high or low will be particularly helpful. Remarks should be accompanied by the number of the cake about which they are made.

Form IIIb

Rating Scale with Abbreviations for Use in Scoring Cakes

Note: For use of investigator only.

Rating	Abbreviations	Numerical scoring expressed as percentage of perfect
Perfect	X	100
Perfect minus	X-	97
Excellent plus	E+	93
Excellent	E	90
Excellent minus	E-	87
Good plus	G+	83
Good	G	80
Good minus	G-	77
Fair plus	F+	73
Fair	F	70
Fair minus	F-	67
Poor plus	P+	63
Poor	P	60
Poor minus	P-	57
Bad plus	B+	53
Bad	B	50